REMARKS

Claims 1-2 remain pending in this application and are rejected. New claims 3-8 are added herein. Claim 1 is amended herein to clarify the invention and to address matters as discussed below.

Claims 1 and 2 are rejected under 35 U.S.C. §112, second paragraph, as being indefinite for not clearly setting forth steps in the claimed method. Similarly, claims 1 and 2 are rejected under 35 U.S.C. §101 as not being directed to patentable subject matter for not setting forth a proper process claim.

Claim 1 is amended herein to more clearly recite method steps thereby overcoming the rejections to the claims.

Claims 1 and 2 are rejected under 35 U.S.C. §102(b) as being anticipated by Harada et al. (U.S. Pat. No. 6,110,072).

"A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).

Applicants respectfully traverse the rejection and, alternatively, aver that the claims as amended overcome the rejections because not all the elements as set forth in the claims are found in the cited reference. The Office Action asserts that "Harada shows a control system for an electric oil pump in a transmission that varies the speed of the pump in response to various conditions including vehicle speed." Office Action page 2. However, in contrast to the current invention, the oil pump in Harada is *always* in use when the vehicle is traveling; there is no auxiliary oil pump disclosed in Harada. Even when the vehicle is stationary or in "stationary mode" there is a lowered rotation speed N2 to "guarantee a line pressure supplied" and prevent "the line pressure from reducing more than is necessary." *See* Harada col. 5 lines 7-15. Harada simply discloses varying the speed of the motor driving the pump depending on what line pressure is necessary for proper operation of an automatic transmission. *Id.* Abstract. Since the pump in Harada must always be in use to maintain some line pressure when the vehicle is traveling, Harada is neither directed nor relevant to rotating an electric motor when driven equipment is not being used as recited in the claims. Thus, the claims are not anticipated because Harada does not disclose rotating an electric motor when driven equipment is not being used.

Furthermore, Harada discloses that motor rotation is reduced when the vehicle is slowing down or stationary. *See* Harada col. 5 lines 7-15. In contrast, claim 2 recites that the driven equipment is an oil pump that is *used* when the vehicle engine is at an idle stop. Thus, the current invention calls for *increasing* the rotation rate when the vehicle is stationary because the auxiliary oil pump is activated and used to supply the line pressure. In an effort to further clarify this distinction with the cited reference, new claim 3 has been added. The new claim 3 is supported by the discussion in the first paragraph on page 20 of the original specification. New claim 4 that is added herein appends the structural limitation of claim 2 to new claim 3.

In addition, Harada does not disclose intermittent rotation. Harada discloses two rotation speeds N1 and N2. *See* col. 3 lines 11-20. The speeds may be varied based upon several variables such as oil temperature and line pressure. However, there is no discussion in Harada of intermittent rotation at either of the rotation speeds. Moreover, as discussed above, the oil pump in Harada is*always* in use. Thus, Harada does not disclose and there is not even a suggestion to intermittently rotate a vehicle oil pump motor. New claim 5 is equivalent to claim 1 except that it is only directed to the embodiment of the invention where the vehicle electric motor is rotated intermittently. In addition new claims 6-8 have

been added herein to further distinguish the embodiment of the invention where the vehicle electric motor is rotated intermittently. New Claim 6 is supported by the discussion in the last paragraph on page 12, bridging pages 12 and 13, first full paragraph on page 15, first full paragraph on page 17, specification . New Claims 7 and 8 are supported by the discussion in last paragraph on page 16, bridging pages 16 and 17.

Applicants submit herewith a substitute specification in accordance with 37 CFR 1.125(b), wherein amendments are effected to place the text thereof into proper form by fixing typographical errors, removing non-standard headings, inserting standard headings, and removing references to the claims. Also accompanying this amendment is a reproduction of the original specification and abstract with markings indicating the amendments effected in the substitute specification in accordance with MPEP §608.01(q) and 37 CFR 1.125(c). No new matter is added. Entry of the substitute specification and abstract is respectfully requested.

No fee is believed due. If there is any fee due the USPTO is hereby authorized to charge such fee to Deposit Account No. 10-1250.

In light of the foregoing, the application is now believed to be in proper form for allowance of all claims and notice to that effect is earnestly solicited.

Respectfully submitted,
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enc: Substitute Specification; and Marked reproduction of original specification.

~~[Designation of Document] Description~~

~~[Title of the Invention]~~ TITLE OF THE INVENTION ~~Method of operating a vehicle electric motor~~

METHOD OF OPERATING A VEHICLE ELECTRIC MOTOR

~~[Technical Field]~~ BACKGROUND OF THE INVENTION

~~[0001]~~

The present invention relates to a method of operating a vehicle electric motor for driving vehicle-mounted driven equipment such as an auxiliary oil pump which supplies a hydraulic pressure of an ATF to a transmission at, for example, an idle stop of an engine, in order to protect a rolling bearing which pivotally supports a rotation shaft of the electric motor.

~~[Background Art]~~

~~[0002]~~

In an automobile having an AT (Automatic Transmission), as shown in Fig. 3, the rotation of an engine 1 which is an internal combustion engine is usually changed in speed by a transmission 3 via a torque converter 2, and transmitted to driving wheels which are not shown. The transmission 3 uses an ATF (Automatic Transmission Fluid) as a hydraulic pressure for speed change, and lubrication. The ATF is circulatively supplied from a drain 5 to the transmission 3 by a main oil pump 4 which operates with using the rotation of the engine 1 as a driving force. Although illustration is omitted, also the torque

converter 2 receives a supply of the ATF as a power transmission medium fluid from the main oil pump 4. In the figure, I_1 indicates various kinds of drive information, and P_1 indicates a driving power source at an idle stop.

~~[0003]~~

Among such automobiles, there is an automobile which is equipped with an idle stop function of, in idling operation of the engine 1, stopping the engine 1 by an idle stop controller 6, thereby intending to improve the fuel efficiency and conserve the environment. The idle stop controller 6 controls the engine 1 on the basis of various kinds of drive information such as the travel speed of the automobile, the position of a select lever, and an operation on a pedal. At stopping of the automobile due to a stoplight, a traffic jam, or the like, such as the case where a brake pedal is depressed and the automobile is stopped while being gradually decelerated, the engine 1 is stopped.

~~[0004]~~

When it is predicted that traveling is again started, such as the case where the foot gets off the brake pedal, the engine 1 is restarted. When it is predicted that traveling is immediately restarted, such as the case where the automobile is suddenly stopped, or when the burden of restart of the engine 1 is large, such as the case where the temperature of the engine 1 is low, or the remaining battery capacity is small, the engine 1 is not stopped.

~~[0005]~~

When the engine 1 is stopped by the idle stop function during stopping of the automobile, however, the main oil pump 4 is caused not to operate, and the supply of the ATF to the transmission 3 and the like is cut off so that the hydraulic pressure is lowered. In a situation such as that an acceleration pedal is depressed down immediately after the engine 1 is restarted, even when the supply of the ATF is restarted by the main oil pump 4, the hydraulic pressure is not instantly restored. Consequently, there is a case where smooth restart of traveling is disabled because, for example, the engine 1 once enters the idling state and the automobile is then suddenly started by the restored hydraulic pressure.

~~[0006]~~

In order to comply with this, conventionally, the supply of the ATF is performed also by an auxiliary oil pump 8 driven by an electric motor 7, in addition to the main oil pump 4, so that, when the engine 1 is stopped by the idle stop function, the hydraulic pressure can be maintained by the auxiliary oil pump 8. Namely, when the engine 1 is stopped by the idle stop function, the idle stop controller 6 supplies the driving power source to the electric motor 7 to cause the auxiliary oil pump 8 to operate, during a period when the engine 1 is stopped.

~~[0007]~~

Various configurations in which the electric motor 7 and the auxiliary oil pump 8 are integrated with each other to facilitate installing of them into an

automobile have been proposed (for example, see Japanese Patent Publication (Kokai) No. HEI9-32738).

~~[0008]~~

The applicant has already proposed an electric pump in which, as shown in Fig. 4, the electric motor 7 and the auxiliary oil pump 8 are integrated with each other, and a rotation shaft 9 that is shared by the electric motor 7 and the auxiliary oil pump 8 is pivotally supported at the both ends by ball bearings 10, 11 (see Japanese Patent Application No. 2003-23524 "Electric internal gear pump"). In the electric motor 7 of the electric pump, permanent magnets 7a are placed in the rotor, and coils 7c are wound around a core 7b of the stator. The motor is used as a sensorless motor. As the auxiliary oil pump 8, a trochoid pump is used in which an inner rotor 8b having an external gear meshes with the inner peripheral side of an outer rotor 8a having an internal gear, and the rotors 8a, 8b are placed eccentrically and rotatably.

~~[Disclosure of the Invention]~~

~~[Problems that the Invention is to Solve]~~

~~[0009]~~

In the case where the above-described electric pump is used as the electric motor 7 and auxiliary oil pump 8 having the idle stop function shown in Fig. 3, only when the automobile is stopped, the electric motor 7 is rotated by the idle

stop controller 6, and, during traveling of the automobile, the electric motor 7 is always stopped.

~~[0010]~~

In the ball bearings 10, 11 which pivotally support the rotation shaft 9 of the electric motor 7 and the auxiliary oil pump 8, during a period when the rotation shaft 9 is stopped, however, plural balls 10a, 11a which are rolling elements are stopped on raceway surfaces of outer rings 10b, 11b and inner rings 10c, 11c. When, in this state, repeatedly subjected to vibrations due to traveling of the automobile, the balls 10a, 11a repeatedly collide against the same places of the raceway surfaces, so that impressions are easily formed. In the rotor of the electric motor 7, particularly, the shaft diameter is often increased in order to obtain a larger torque. Since the permanent magnets 7a shown in Fig. 3, and the like are placed, the rotation shaft 9 has a relatively heavy weight. Therefore, impacts which are produced when the balls 10a, 11a receiving vibrations collide against the raceway surfaces are large.

~~[0011]~~

In the case where the rotation shaft 9 of the electric motor 7 used for the idle stop function is pivotally supported by the ball bearings 10, 11, consequently, there is conventionally a problem in that impressions are easily formed on the outer rings 10b, 11b and inner rings 10c, 11c of the ball bearings 10, 11, and the life periods of the bearings are shortened.

~~[0012]~~

The problem is not restricted in the electric pump in which the electric motor 7 and the auxiliary oil pump 8 are integrated with each other, and occurs similarly in the case where the single electric motor 7 is used. The problem is not restricted in the ball bearings 10, 11, and occurs similarly in the case where rolling bearings including various roller bearings are used. Furthermore, the problem is not restricted in the electric motor 7 used for the idle stop function, and occurs commonly in an electric motor for driving driven equipment which is sometimes in no use for a long term during when a vehicle travels.

~~[0013]~~

It is an object of the invention to solve the problem in that, when an electric motor is not rotated for a long term during when a vehicle travels, the life period of a rolling bearing which pivotally supports the rotation shaft of the electric motor is shortened.

~~[Means for solving the Problems]~~ <u>BRIEF SUMMARY OF THE INVENTION</u>

~~[0014]~~

The invention ~~of claim 1~~ <u>according to a first embodiment</u> is characterized ~~in that, in~~ <u>by</u> a method of operating a vehicle electric motor which drives driven equipment via a rotation shaft that is pivotally supported by a rolling bearing, the

electric motor is rotated at a very low speed or in an intermittent manner when a vehicle is traveling and the driven equipment is not used.

~~[0015]~~

The invention ~~of claim 2~~ according to a second embodiment is characterized in that the driven equipment is an auxiliary oil pump for supplying a hydraulic pressure of an ATF to a transmission, only at an idle stop of an engine.

~~[0016]~~

It is not always necessary to independently detect a period when the vehicle is traveling, and that when the driven equipment is not used. In a usual idle stop function, for example, an idle stop controller or the like performs a control in which, when a vehicle is traveling, an auxiliary oil pump is not always used. Therefore, a judgment by the idle stop controller or the like whether the vehicle is traveling or not may be used as a judgment whether "the vehicle is traveling and the driven equipment is not used" or not.

~~[0017]~~

According to the first embodiment of the invention ~~of claim 1~~, when the vehicle is traveling so that there is a possibility that the rolling bearing receives vibrations, and when the driven equipment is not used and a rotation shaft of the electric motor is stopped, the electric motor is rotated at a low speed or in an intermittent manner. Even when the vehicle receives vibrations as a result of traveling, therefore, the rotation shaft is slightly rotated, and positions on raceway

surfaces of balls or rollers of the rolling bearing are changed upon occasion. Consequently, there is no possibility that impressions are formed in the raceway surfaces, and it is possible to prevent the life period of the rolling bearing from being shortened. When the vehicle is not traveling, the rolling bearing does not receive vibrations, and hence the electric motor is not necessary to be rotated. When the driven equipment is not used, the electric motor is appropriately rotated, and hence it is not necessary to control the electric motor so as to be further rotated.

~~[0018]~~

According to the second embodiment of the invention ~~of claim 2~~, a rolling bearing of the electric motor for the auxiliary oil pump which operates only at an idle stop of the engine, and which, in another case, does not operate and continues to receive vibrations during traveling for a long term can be surely protected.

~~[Brief Description of the Drawings]~~ BRIEF DESCRIPTION OF THE DRAWINGS

~~[0019]~~

~~[Fig. 1]~~ Fig. 1 is a block diagram showing an embodiment of the invention, and of a drive controller for an electric motor which drives an auxiliary oil pump for an idle stop.

~~[Fig. 2]~~ Fig. 2 is a time chart showing the embodiment of the invention, and a traveling state of an automobile, and a driving power source for supplying to the electric motor which drives the auxiliary oil pump for the idle stop.

~~[Fig. 3]~~ Fig. 3 is a block diagram showing a conventional example, and of a drive controller for an electric motor which drives an auxiliary oil pump for an idle stop.

~~[Fig. 4]~~ Fig. 4 is a longitudinal section side view illustrating the structure of an electric pump consisting of an auxiliary oil pump for an idle stop, and an electric motor for driving it.

~~[Description of the Reference Numerals]~~

~~[0020]~~

~~1 engine~~

~~2 torque converter~~

~~3 transmission~~

~~4 main oil pump~~

~~6 idle stop controller~~

~~7 electric motor~~

~~8 auxiliary oil pump~~

~~9 rotation shaft~~

~~10 ball bearing~~

~~11 ball bearing~~

~~12 ball bearing protection drive controller~~

~~I_1 drive information~~

~~I_2 in-traveling information~~

~~P_1 driving power source at idle stop~~

~~P_2 driving power source for protecting ball bearings~~

~~[Best Mode for Carrying Out the Invention]~~ DETAILED DESCRIPTION OF THE INVENTION

~~[0021]~~

Hereinafter, the best embodiment of the invention will be described.

The embodiment is a method of operating the electric motor 7 for the auxiliary oil pump 8 used in an idle stop function of an AT vehicle, and shown in Fig. 3. The electric motor 7 and the auxiliary oil pump 8 are integrated with each other with sharing the rotation shaft 9, as shown in Fig. 4. Also in Fig. 1, the components having the same functions as those of the conventional example shown in Fig. 3 are denoted by the identical reference numerals. In the figure, the symbol I_1 indicates various kinds of drive information, I_2 indicates in-traveling information, P_1 indicates a driving power source at an idle stop, and P_2 indicates a driving power source for protecting the ball bearings.

~~[0022]~~

In the same manner as the case shown in Fig. 3, during when the vehicle is stopped, also the idle stop controller 6 of the embodiment shown in Fig. 1 stops

the engine 1 on the basis of various kinds of drive information such as the travel speed of an automobile and a driving operation. Namely, the idle stop controller 6 does not stop the engine 1 during when the automobile is traveling. It is possible to judge whether the automobile is traveling or not, by detecting, for example, the travel speed of the automobile.

~~[0023]~~

All cases where the automobile moves even at a slight degree may be judged as the traveling state. Alternatively, for example, only a case where the automobile travels at a speed more than a predetermined value may be judged as the traveling state, in order to exclude a predetermined initial time period of movement or traveling at a very low speed. In this case, judgment that the automobile is not traveling, i.e., the automobile is stopping includes cases where the automobile is traveling immediately after start of movement, and where the automobile is traveling at a speed lower than a predetermined value.

~~[0024]~~

The traveling speed may be detected from a rotation speed of a driving wheel, a propeller shaft, or the like. Alternatively, the traveling speed may be calculated, for example, by detecting a magnetic marker of a position information system or a road, or the like, or by detecting and time-integrating the acceleration in the traveling direction of the automobile. The in-traveling information in which

the idle stop controller 6 judges in this way whether the automobile is traveling or not is sent to a ball-bearing protection drive controller 12.

~~[0025]~~

During when the automobile is stopping, only in the case of stopping due to, for example, a stoplight, a traffic jam, or other usual temporary stopping, the idle stop controller 6 stop the engine 1 by the idle stop function, and, in the case where the automobile is suddenly stopped, or where the burden of restart of the engine 1 is large, the idle stop controller does not stop the engine 1. When the engine 1 is stopped by the idle stop function, the idle stop controller 6 supplies the driving power source at an idle stop to the electric motor 7 for the auxiliary oil pump 8 to continuously rotate the electric motor 7.

~~[0026]~~

When the engine 1 is stopped in this way, the supply of the ATF from the main oil pump 4 to the transmission 3 and the like is stopped. By rotating the electric motor 7, the auxiliary oil pump 8 provides substitution of the supply of the ATF. In the same manner as the conventional art, therefore, the hydraulic pressures of the transmission 3 and the like at an idle stop can be maintained.

~~[0027]~~

In the embodiment, a sensorless motor is used as the electric motor 7. Therefore, a driver circuit for the sensorless motor detects the counter electromotive forces induced in the coils 7c of the stator shown in Fig. 4 to

estimate the rotational position of the rotor, converts a DC power source to an alternate current by an inverter in accordance with the estimated rotational position, and supplies the alternate current to the coils 7c. Consequently, the idle stop controller 6 can rotate the electric motor 7 simply by supplying the DC power source to the driver circuit for the electric motor, and can perform also a speed control by changing the power source voltage. Furthermore, the speed control can be set also as a feedback control by obtaining information of rotation speed of the rotor from the driver circuit.

~~[0028]~~

When receiving from the idle stop controller 6 the in-traveling information of judgment that the automobile is traveling, the ball-bearing protection drive controller 12 supplies the driving power source for protecting the ball bearings to the electric motor 7 for the auxiliary oil pump 8, to rotate the electric motor 7. The driving power source for protecting the ball bearings is a DC power source for performing intermittent rotation in which the electric motor 7 is rotated only for a short time period such as several seconds at relatively long time intervals such as several minutes.

~~[0029]~~

Therefore, the driving power source for protecting the ball bearings is formed as pulses in which the duty ratio is very small, and, even when the power source is supplied for a long time, the power consumption is extremely small.

Furthermore, even when the electric motor 7 is intermittently rotated in this way and the auxiliary oil pump 8 operates, the main oil pump 4 operates during traveling, and hence the supply of the ATF to the transmission 3 and the like is never affected.

~~[0030]~~

As described above, the ball-bearing protection drive controller 12 causes the electric motor 7 to be intermittently rotated. When the in-traveling information from the idle stop controller 6 is switched to that of judgment that the automobile is stopping, the controller stops the supply of the driving power source for protecting the ball bearings. In accordance with this, also rotation of the electric motor 7 is stopped.

~~[0031]~~

In the case where the idle stop controller 6 stops the engine 1 by the idle stop function, however, the driving power source at an idle stop is supplied, and hence the electric motor 7 is continuously rotated. In the case where the idle stop controller 6 does not stop the engine 1 even when the automobile is stopping, the main oil pump 4 supplies the ATF, and therefore the driving power source at an idle stop is not supplied to the electric motor 7.

~~[0032]~~

According to the configuration, when the automobile starts and begins to travel at, for example, time t_0 shown in Fig. 2, the idle stop controller 6 sends the

in-traveling information of judgment that the automobile is traveling, to the ball-bearing protection drive controller 12. Therefore, the ball-bearing protection drive controller 12 supplies the driving power source for protecting the ball bearings to the electric motor 7. The driving power source for protecting the ball bearings is a pulse-like DC power source which rotates (ON) the electric motor 7 for a short time period T_{ON}, for example, from time t_1 to time t_2, thereafter stops (OFF) the electric motor 7 for a relatively long ~~tome~~ time period T_{OFF} from time t_2 to time t_3, and repeats this at intervals of period $T_{ON}+T_{OFF}$.

~~[0033]~~

Even when the ball bearings 10, 11 which pivotally support the rotation shaft 9 of the electric motor 7 shown in Fig. 4 receive vibrations as a result of traveling of the automobile, therefore, the electric motor 7 is intermittently rotated, and the balls 10a, 11a change upon occasion their positions on the raceway surfaces of the outer rings 10b, 11b and the inner rings 10c, 11c. Consequently, there occurs no case where impressions are formed in the raceway surfaces.

~~[0034]~~

In the case where, even when the electric motor 7 is repeatedly rotated only for the period T_{ON}, the balls 10a, 11a thereafter stop at the same positions on the raceway surfaces every time or periodically, the length of, for example, the time period T_{ON} is slightly changed each time. In the case where the rotational

angle of the rotor of the electric motor 7 can be detected, the control can be made so that, after rotation of the period T_{ON}, the rotational angle is distributed with being uniformly dispersed over the whole circumference.

~~[0035]~~

When the automobile is gradually decelerated by depressing the brake pedal and stops at time t_4, the in-traveling information from the idle stop controller 6 is switched to that indicative of stopping, and hence the ball-bearing protection drive controller 12 stops the supply of the driving power source for protecting the ball bearings to the electric motor 7. The idle stop controller 6 judges such stopping as usual stopping due to a stoplight, a traffic jam, or the like, and therefore stops the engine 1 by the idle stop function and supplies the driving power source at an idle stop to the electric motor 7, so that the electric motor is continuously rotated after time t_4.

~~[0036]~~

In the embodiment, the electric motor 7 for the auxiliary oil pump 8 which is used in the idle stop function has been described, and therefore the auxiliary oil pump 8 is always set not to be used when the automobile is traveling (however, the period when the auxiliary oil pump 8 is not used is not always the period when the automobile is traveling). Therefore, the ball-bearing protection drive controller 12 judged whether the driving power source for protecting the ball

bearings is to be supplied to the electric motor 7, based on only the in-traveling information.

~~[0037]~~

Depending on various hybrid vehicles, however, there is a case where, even when traveling, fuel injection is stopped during, for example, regenerative breaking to stop the engine 1. In this case, when the main oil pump 4 operates in accordance with only rotation of the engine 1, the main oil pump 4 is stopped also during traveling. In the same manner as the idle stop function, therefore, the necessity for rotating the electric motor 7 to cause the auxiliary oil pump 8 to operate arises. In such a case, consequently, even when traveling, a judgment whether the ball-bearing protection drive controller 12 is using the auxiliary oil pump 8 or not is made, so that, if not used, the driving power source for protecting the ball bearings is supplied to the electric motor 7.

~~[0038]~~

It is a matter of course that, if not necessary even when the automobile is traveling, a driving mechanism for a wiper, a power window, or the like is not used for a long term. If necessary, it is used irrespective of whether the automobile is traveling or stopping. Moreover, the stop position in no use of the wiper, the power window, or the like is predetermined. Therefore, also the stop angle position of the rotation shaft of the electric motor which rotates the driving

mechanism is constant, and there is the possibility that the burden on the ball bearings due to vibrations during traveling is particularly increased.

~~[0039]~~

Therefore, the driven equipment which is rotated by the electric motor is not restricted to the auxiliary oil pump 8, and includes various equipment mounted on the automobile, such as driving mechanisms for the wiper, the power window, and the like. An electric motor which rotates such driven equipment must be usually controlled while independently detecting traveling of the automobile and no use of the driven equipment.

~~[0040]~~

The no use of the driven equipment may include a case where the driven equipment is not required to operate, and that where it must not operate entirely or at a degree larger than a predetermined one. In the case of the auxiliary oil pump 8 which is shown in the embodiment, for example, it is set to no use when at least the engine 1 rotates, and in this situation it is not necessary to supply the ATF. By contrast, in a driving mechanism for the wiper, the power window, or the like, no use is set in the case where it is not manipulated so as to operate, and, in the no use, it must not operate basically.

~~[0041]~~

In the embodiment, the case where the ball-bearing protection drive controller 12 controls the electric motor 7 so as to be intermittently rotated has

[[bee]] been described. Since it is requested to sufficiently reduce the power consumption, the electric motor may be rotated at a very low speed. The very low speed means rotation in which the electric motor is rotated at a speed that is sufficiently lower than an average rotational speed of the electric motor in use of the driven equipment. Even in use of the driven equipment, there is a case where the electric motor is stopped momentarily or temporarily or rotated at an extremely low speed. Therefore, the very low speed is not always required to be lower than the minimum speed of the electric motor in use. In the case where the rotational speed in use has the lower limit and the minimum speed is a rotational speed which is sufficiently high, as in the case of the electric motor 7 in the embodiment, the very low speed is ought to be sufficiently lower than the minimum speed in order to save the electric power.

~~[0042]~~

In the embodiment, the case where the electric motor 7 configured by a sensorless motor is used has been described. Another electric motor such as a brushless motor or an induction motor may be used. The driving power source for protecting the ball bearings which is supplied by the ball-bearing protection drive controller 12 is not restricted to a DC power source, and a power source corresponding to the kind of the electric motor is supplied.

~~[0043]~~

Alternatively, in place of the supply of the driving power source to the electric motor, a control signal may be sent to the driver circuit, so that intermittent rotation or very low-speed rotation may be performed by a control of the driver circuit. This may be similarly applicable also to the driving power source of the idle stop controller 6 at an idle stop.

~~[0044]~~

In the embodiment, the case where the supply of the ATF is not affected even when the electric motor 7 is rotated during traveling and the auxiliary oil pump 8 operates has been described. In a driving mechanism for the wiper, the power window, or the like, in no use, or when it is not manipulated so as to operate, the mechanism must not operate basically as described above. In such a driving mechanism, however, it is possible to rotate only the electric motor within the play range of a transmission apparatus. Therefore, the ball-bearing protection drive controller 12 may rotate the electric motor so as to repeatedly reciprocate within the range. Furthermore, there is a case where it is allowed to actually operate a wiper, a window glass, or the like within a range where passengers do not notice the movement. Therefore, the rotation may be conducted so as to repeatedly reciprocate within the range.

~~[0045]~~

In the invention described above, the control is made while detecting that the automobile is traveling. Alternatively, an operating method may be employed

in which an acceleration sensor is attached to an automobile or an acceleration sensor that has been already provided for another purpose is used, and, in the case where the acceleration is not smaller than a predetermined value, and driven equipment is in no use, an electric motor is rotated at a very low speed or in an intermittent manner. When such an acceleration sensor is used, it is possible to make a control, not during traveling in which there is the possibility of receiving vibrations, but only when actually receiving vibrations. Therefore, a situation in which the electric motor is rotated during traveling which is very smooth and vibration free to wastefully consume the electric power can be prevented from occurring.

~~[0046]~~]

In the embodiment, the acceleration sensor can optimumly detect only vibrations which may adversely affect the ball bearings 10, 11 pivotally supporting the rotation shaft 9 of the electric motor 7 and the auxiliary oil pump 8. Therefore, it is preferable to place the acceleration sensor in the vicinity of the transmission 3 or the electric motor 7 and the auxiliary oil pump 8, and it is preferable to dispose the sensor so as to detect an acceleration of the rotation shaft 9 in a radial direction.

~~[0047]~~

In the embodiment, the case where the rotation shaft through which the electric motor rotates the driven equipment is pivotally supported by the ball

bearings 10, 11 has been described. A place where impressions may be formed by vibrations is not restricted to the ball bearings 10, 11, and is commonly applied to a usual rolling bearing which uses rolling elements. The same is applicable also to various roller bearings.

~~[0048]~~

In the embodiment, the electric pump in which the electric motor 7 and the auxiliary oil pump 8 share the rotation shaft 9 and are integrated with each other has been described. It is not necessary to integrate the electric motor and the driven equipment in this way. Alternatively, the rotation shaft of the electric motor may be coupled to the driven equipment via a joint or another transmission device.

~~[0049]~~

In the embodiment, the automobile has been described. The invention can be embodied in any vehicle as far as the vehicle travels on a road or track and receives vibrations during traveling. It is not always restricted to a vehicle which comprises an engine as a source of power.

~~[Industrial Applicability]~~

~~[0050]~~

As described above, according to the invention, in the case where the driven equipment is not used and the rotation shaft of the electric motor is stopped, even when the vehicle receives vibrations as a result of traveling, the

rotation shaft is slightly rotated, and positions on raceway surfaces of balls or rollers of the rolling bearing are changed upon occasion. Consequently, there is no possibility that impressions are formed in the raceway surfaces, and it is possible to prevent the life period of the rolling bearing from being shortened.

~~[0051]~~

Furthermore, a rolling bearing of the electric motor for the auxiliary oil pump which operates only at an idle stop of an engine, and which, in another case, does not operate and continues to receive vibrations during traveling for a long term can be surely protected.